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**FEASIBILITY OF USING HANDRAILS TO MOVE  
ALONG A SURFACE WHILE WEIGHTLESS**

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*EDWIN H. SASAKI*

## FOREWORD

This study was conducted by the Crew Stations Branch, Human Engineering Division, Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, in support of Project 7184, "Human Performance in Advanced Systems," Task 718405, "Design Criteria for Crew Stations in Advanced Systems." This study was begun in June 1964 and completed in October 1964.

The author makes acknowledgement to Colonel Lloyd R. Hayes (retired), MSgt Charles W. Sears, and SSgt Estell P. Bunch for their invaluable assistance in monitoring the airborne tests.

This technical report has been reviewed and is approved.

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## ABSTRACT

A preliminary investigation into the feasibility of using handrails as an aid to the astronaut in moving from one location to another within or outside a space vehicle was undertaken in a JC-131B zero-G airplane. Eight subjects wearing flying coveralls (one of whom also performed the tests wearing an inflated full-pressure suit) moved from one point to another aided by a single handrail or two parallel handrails. Eight conditions were investigated with the parallel handrails spaced from 6 to 36 inches apart and one with the single handrail. All subjects were successful in moving across the surface and turning around using both the single and parallel handrails. Motion picture films were taken to evaluate the body positions and ease of movement. The most common position appeared to be one in which the elbows and knees were slightly bent and the torso was nearly parallel to the surface. The parallel handrails spaced from 16 to 24 inches apart appeared to provide the greatest body stability.

## SECTION I

### INTRODUCTION

Future space missions will certainly require that the astronaut move from one point to another within the vehicle, or on its surface to a worksite, or from hatch to hatch. Although many concepts exist on techniques to aid the astronaut in moving from one location to another, one that appears particularly promising is the use of handrails. To investigate the feasibility of this technique, the following preliminary experiment was conducted.

## SECTION II

### METHODS

A 1-inch sheet of plywood (96 inches long by 48 inches wide) was bolted to the floor of the cabin of a JC-131B zero-G research airplane, so that the longitudinal centerline of the plywood surface made a  $50^\circ$  angle with the centerline of the airplane. A slot cut in the plywood at each end allowed installation of either a single handrail or parallel handrails that could be adjusted for distances from 6 to 36 inches apart. The handrails were smooth aluminum pipes, 1.25 inch in diameter and 84 inches long, with mounting blocks on each end that provided a 2-inch clearance between the bottom of the rail and the plywood surface.

Nine conditions were investigated: one in which a single handrail was used and eight in which two parallel handrails were spaced 6, 12, 16, 18, 20, 24, 30, or 36 inches apart. The conditions were randomly presented.

Eight subjects, well experienced in working under conditions of weightlessness in the zero-G research plane, participated in the experiment. The K-2B summer flying coveralls were worn by all subjects during the trials, and one subject repeated the experiment wearing the Air Force A/P-22S-2 full-pressure suit inflated to 3.5 psi.

The subjects were instructed to grasp the rail (or rails) near one end when the weightless portion of the zero-G parabola was attained, to move along the surface using the rail, and to turn around when they reached the other end. This maneuver constituted one trial. They were told to remain at that end until the following parabola, at which time they were to return to the starting position in the same manner, again turning around when they reached the opposite end. This procedure was repeated for 18 trials. The subjects received no practice trials and were given no instructions concerning speed or technique of moving and turning around. All trials were photographed

by a 16 mm motion picture camera. No measures of time or force were taken. When each subject completed the 18 trials he was asked to comment on any difficulties he may have had and to state which condition or conditions seemed to be the most comfortable.

### SECTION III

#### RESULTS AND DISCUSSION

All the subjects were successful, on all trials, in moving from one position to another and in turning around. Furthermore, they were generally able to use their wrists in exerting sufficient torque on the rails to cancel any gross body rotation, e.g., heels-over-head. Only one subject (wearing coveralls), in one instance, did a handstand and then lost control when he stopped suddenly at one end (fig. 1), apparently having moved too rapidly. Except for this one case, all the subjects were able to maintain a fairly "good" body position/control as they moved and turned around. For most subjects, this good body position appeared to be one in which the elbows and knees were slightly bent and the torso was nearly parallel to the surface (figs. 2,3). However, one subject (wearing coveralls) consistently moved with his legs "tucked" as shown in figure 4.

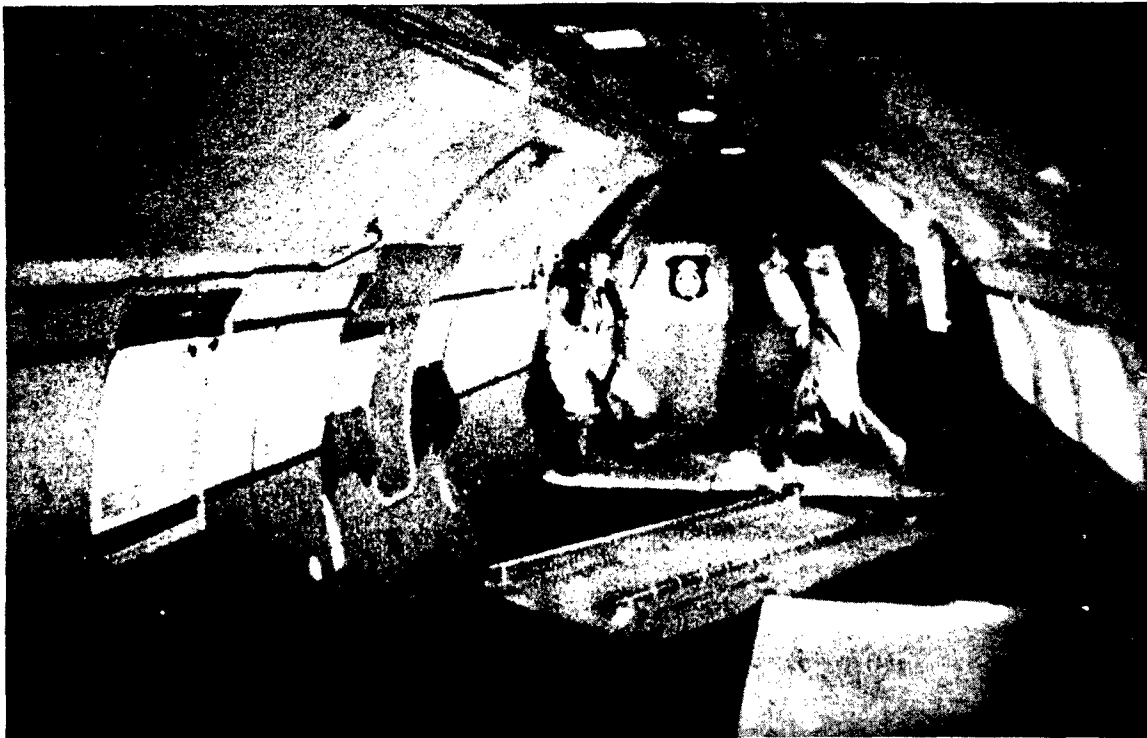
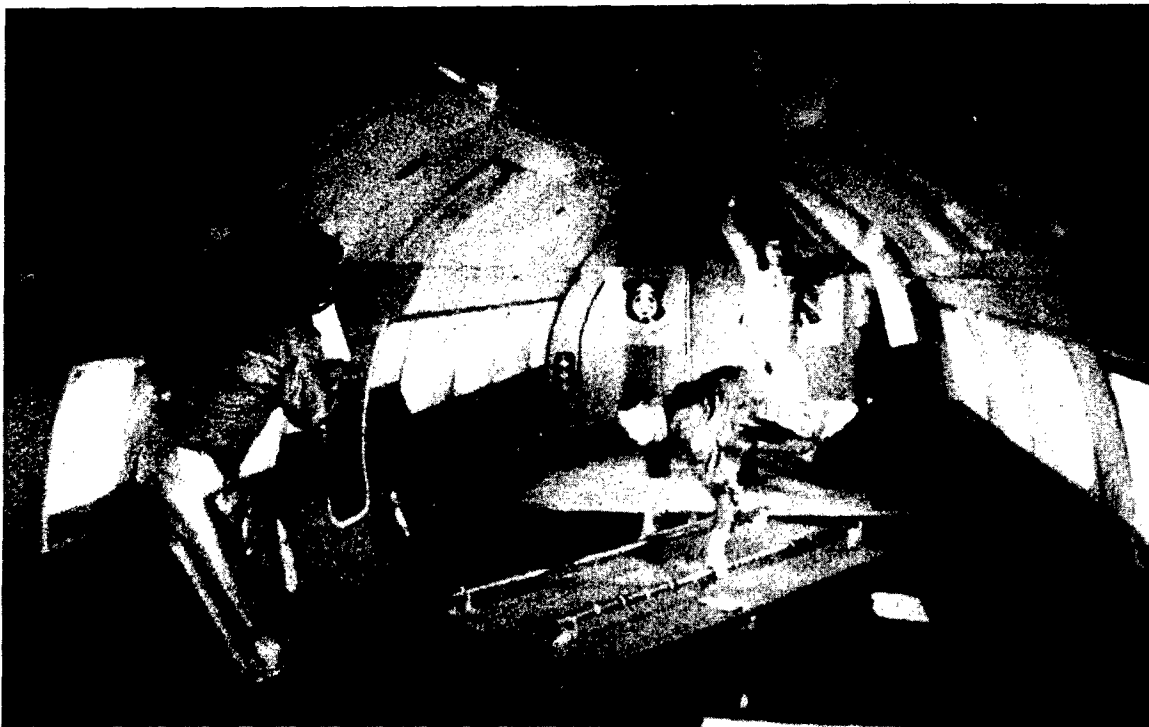
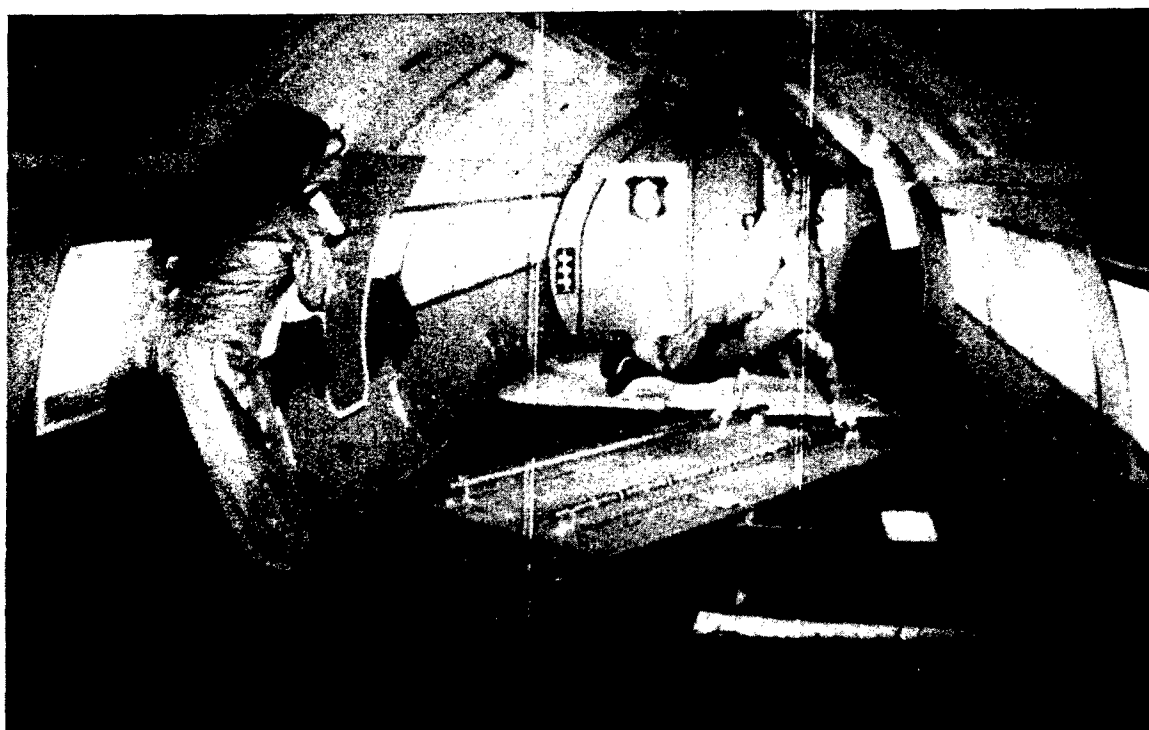


Figure 1. Subject in Handstand Position  
at the End of the Handrails



TRANSLATION



TURN-AROUND

Figure 2. Subject (Wearing Flying Coveralls)  
in "Good" Body Position



TRANSLATION



TURN-AROUND

Figure 3. Subject (Wearing Inflated Full-Pressure Suit) in "Good" Body Position

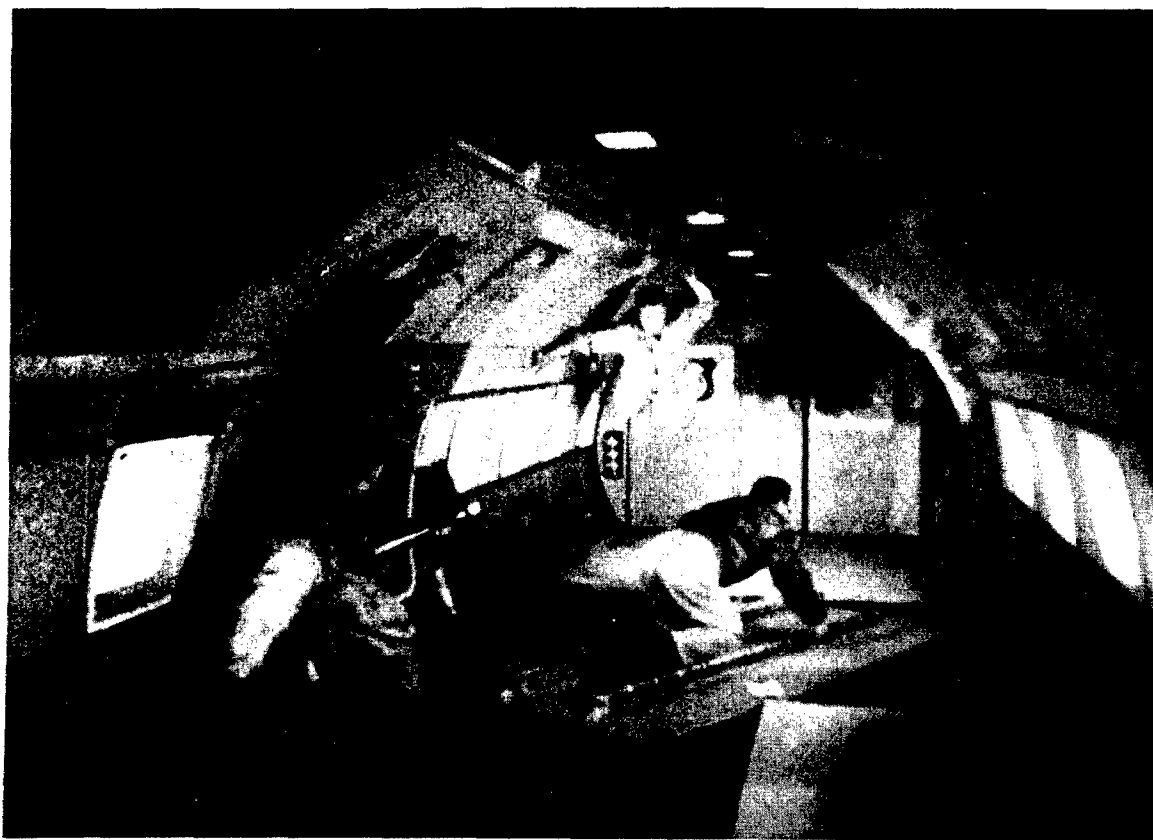


Figure 4. Subject Moving with His Legs "Tucked"

Based on an evaluation of the film, the single rail and parallel rails with 6- or 12-inch separations appeared to offer the least body stability in terms of roll oscillations about the handrails. Once a subject's body started to sway, he had difficulty stopping and, in a few cases, some subjects could not stop the oscillations before hitting the surface (fig. 5). The subjects, themselves, may not have started their bodies swaying, rather, the airplane may have induced the oscillations.

All subjects (including the subject wearing the inflated pressure suit) reported that the 16- to 24-inch separations felt the most comfortable. These conditions were probably more comfortable because they were close approximations of the subjects' shoulder breadths.

Only the subject wearing the inflated full-pressure suit reported that the 30- and 36-inch separations were definitely uncomfortable. The subject had to "fight" the restraint of the pressure suit to extend his arms out to the two rails. In addition, the pressure suit helmet restricted the subject's view so that he could see only one rail at a time, and then, only when he turned his head to one side.

In summary, this investigation must be considered preliminary, primarily because of its qualitative nature and the small number of subjects. However, the experiment does demonstrate the feasibility of an astronaut using two parallel handrails, but not a single handrail, to move from one position to another within the space vehicle or on its surface. Furthermore, the experiment suggests that a satisfactory spacing, at least for shirt-sleeved subject, is in the range from 16 to 24 inches between rails.



Figure 5. Subject Hitting the Surface While Moving

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